

**Geologic Resources Inventory Workshop Summary
Glen Canyon National Recreation Area and
Rainbow Bridge National Monument
*September 23-25, 1999***

**National Park Service
Geologic Resources Division
and
*Natural Resources Information Division***

Version: Draft of October 22, 1999

EXECUTIVE SUMMARY

An inventory workshop was held at Glen Canyon NRA and Rainbow Bridge NM on September 23-25, 1999 to view and discuss the park's geologic resources, to address the status of geologic mapping by both the Utah Geological Survey (UGS) and the United States Geological Survey (USGS) for compiling both paper and digital maps, and to assess resource management issues and needs. Cooperators from the NPS Geologic Resources Division (GRD), Natural Resources Information Division (NRID), Glen Canyon NRA, UGS, and USGS were present for the two-day workshop. ([**See Appendix A, Glen Canyon NRA and Rainbow Bridge NM Geological Resources Inventory Workshop Participants, September 23-25, 1999**](#))

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Day one involved a "land" field trip co-led by USGS geologists Pete Peterson and George Billingsley.

Highlights of the field trip can be found at
http://www.nature.nps.gov/grd/geology/gri/ut/glca/field_trip_glca

Day two involved a scoping session to present overviews of the NPS Inventory and Monitoring (I&M) program, the Geologic Resources Division, and the ongoing Geologic Resources Inventory (GRI) for Colorado and Utah. Round table discussions involving geologic issues for Glen Canyon NRA and Rainbow Bridge NM included interpretation, soils mapping, paleontologic resources, the UGA Millennium 2000 guidebook featuring the geology of Utah's National and State parks, the status of cooperative geologic mapping efforts, sources of available data, geologic hazards, potential future research topics, and action items generated from this meeting. Brief summaries of each follow.

Day three involved a "water" field trip to Rainbow Bridge and the southern reaches of Lake Powell led by UGS geologists Grant Willis, Doug Sprinkel and Tom Chidsey.

OVERVIEW OF GEOLOGIC RESOURCES INVENTORY

After introductions by the participants, Joe Gregson (NPS-NRID) presented an overview of the NPS I&M Program, the status of the natural resource inventories, and the geologic resources inventory ([see Appendix B, Overview of Geologic Resources Inventory](#)).

He also presented a demonstration of some of the main features of the **digital geologic map** for the Black Canyon of the Gunnison NP and Curecanti NRA in Colorado. This has become the prototype for the NPS digital geologic map model as it ideally reproduces all aspects of a paper map (i.e. it incorporates the map notes, cross sections, legend etc.) with the added benefit of being a GIS component. It is displayed in ESRI ArcView shape files and features a built-in help file system to identify the map units. It can also display scanned JPG or GIF images of the geologic cross sections supplied with the map. The cross section lines (ex. A-A') are subsequently digitized as a shape file and are hyperlinked to the scanned images.

For a recap on this process, go to: http://www.nature.nps.gov/grd/geology/gri/blca_cure/
and view the various files in the directory.

The geologists at the workshop familiar with GIS methods were quite impressed with this method of displaying geologic maps digitally; Joe Gregson is to be commended for his accomplishments.

Joe also demonstrated the developing NPS data browser for adding various coverages into GIS projects "on-the-fly". With this functional data browser numerous NPS themes

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can be added to an ArcView project with relative ease. Such themes might include geology, paleontology, hypsography (topographic contours), vegetation, soils, etc.

Bruce Heise (NPS-GRD) followed with an overview of the Geologic Resources Division and the Geologic Resources Inventory and the main goals summarized below:

1. to assemble a bibliography of associated geological resources for NPS units with significant natural resources,
2. to compile and evaluate a list of existing geologic maps for each unit,
3. to develop digital geologic map products, and
4. to complete a geological report that synthesizes much of the existing geologic knowledge about each park. The emphasis of the inventory is not to routinely initiate new geologic mapping projects, but to aggregate existing information and identify where serious geologic data needs and issues exist in the National Park System.

INTERPRETATION

Norm Henderson expressed the following as main interpretive issues for GLCA:

- publication of a geologic map for the entire park for both resource evaluation and sale to the public from the visitor center, similar to the Arizona Geologic Highway Map
- up-to-date soils data
- identification of geologic hazards

The GRI also aims to help promote geologic resource interpretation within the parks and GRD has staff and technology to assist in preparation of useful materials including developing site bulletins and resource management proposal (RMP) statements appropriate to promoting geology. Jim Wood (GRD) and Melanie Moreno (USGS-Menlo Park, CA) have worked with several other NPS units in developing web-based geology interpretation themes, and should be considered as a source of assistance should the park desire.

The UGS has their Geologic Extension Services available for help to the NPS for creating interpretive brochures and for seasonal employee training. The UGS also has programs for applied geology (hazards), economic geology, archeology and paleontology. Their contact person is Sandy Eldredge (nrugs.seldredg@state.ut.us)

UGA GUIDEBOOK ON UTAH'S NATIONAL AND STATE PARK AREAS

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Doug Sprinkel and Tom Chidsey of the UGA announced that a guidebook treating the geology of Utah's national and state parks and monuments would be compiled for publication in September 2000. This compilation will be a snapshot into the geology of each park and covers most facets of what the GRI is trying to develop for each park for a final report (i.e. cross sections, simplified geologic map, general discussions of rocks, structure, unique aspects of park geology, classic viewing localities). The only NPS unit in Utah that will **not** be treated will be Golden Spike National Historic Site.

Funding for this publication is coming jointly from the UGA, NPS, BLM, USFS and Utah state parks; it is hoped that the publication will be sold for under \$30.

Each author will be *encouraged* to get with NPS staff interpreters to develop a product that aims at a wide audience (the common visitor, the technical audience and the teaching community). Glen Canyon NRA and Rainbow Bridge NM authors will be our Lake Powell field trip leaders (Doug Sprinkel, Tom Chidsey and Grant Willis).

Park authors are strongly encouraged to get with NPS staff to make sure that any trail logs do follow maintained trails and do not take visitors into unauthorized areas, or places where resources are fragile and would be disturbed by increased visitation (i.e. areas with cryptogamic soils).

Also, a CD-ROM will be distributed with the publication featuring road and trail logs for specific parks as well as a photo glossary and gallery. The photo glossary will describe certain geologic features (i.e. *what is crossbedding?*). These will also be available as web-downloadable Adobe Acrobat PDF files. The UGA cannot copyright this material because it is funded with state money, so it can be distributed widely and freely, which will also benefit the purposes of the GRI. Additional reprints are not a problem because of the digital nature of the publication and the UGA board is committed to additional printings as needed. UGA normally prints 1000 copies of their publications because they become dated after about five years; that will probably not be an issue for this publication. Prices for the full-color guidebook are estimated to be approximately \$25/copy, and sales are expected to be high (exact estimates for Capitol Reef NP were 125 copies/year). A website for the guidebook is forthcoming in October 1999.

Field Trips will be held in September 2000. Currently, four field trips are scheduled:

1. Arches NP, Canyonlands NP, Dead Horse Point State Park (SP)
2. Antelope Island SP and Wasatch Mountain SP
3. Zion NP, Glen Canyon NRA and Rainbow Bridge NM, Snow Canyon SP and Quail Creek SP
4. Dinosaur NM, Flaming Gorge NRA, and Red Fleet SP

Note: Trips 1 and 2 will run concurrently and Trips 3 and 4 will also run concurrently.

Many other benefits are anticipated from this publication and are enumerated below:

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- This type of project could serve as a model for other states to follow to bolster tourism and book sales promoting their state and its geologic features.
 - Sandy Eldredge (UGS) will be targeting teaching communities for involvement in the field trips; hopefully teachers will pass on what they have learned to their young audience.
 - The language is intended to appeal to someone with a moderate background in geology and yet will be very informative to the educated geologist.
 - The publication may be able to serve as a textbook to colleges teaching Geology of National Parks (in Utah).
 - A welcomed by-product could be roadlogs between parks in Utah for those visiting multiple parks, perhaps with a regional synthesis summarizing how the overall picture of Utah geology has developed.
-

SOILS MAPPING STATUS

Pete Biggam (NRID-Soil Scientist) talked about the I&M program's desire to obtain up-to-date "Order 3" soil surveys for all 265 I&M NPS units. The NPS will partner with the Natural Resources Conservation Service (NRCS) to obtain soil data, as they are the lead agency charged with soils mapping. Currently, GLCA falls under two NRCS management areas (Phoenix-southern portion of GLCA and Lakewood, CO-northern portion).

GLCA currently does have a digitized soils map, but it does not yet meet I&M standards. It has soil polygons and map unit symbols, but is not attributed and would require the end user to consult a text report for decision support.

GLCA soils are mapped and only need merged into a single coverage for the park (i.e. No new mapping is needed), then incorporated with a single legend for use with the digital NPS data browser. The eventual GIS coverage will be similar to the demonstrated geology coverage for Black Canyon of the Gunnison NP with a digital soils map and user help files, including the entire NRCS report as a digital report.

Pete estimates that a soils GIS product will be delivered sometime in 2001-2002 because the GLCA soils map priority is 113 on the I&M list.

Biggam handed out an overview of the current status of soils maps for Glen Canyon as follows:

An interagency agreement between the NPS and the Soil Conservation Service (SCS), now the NRCS, was developed in the late 1970s to provide soils information for Glen

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Canyon NRA. The area covers parts of two soil survey areas in Arizona, and parts of four soil surveys in Utah.

A soils manuscript and a set of soil maps on orthophotography, as well as a digital soils layer were provided to GLCA by the Utah NRCS. Unfortunately, no soil attributes were developed in an electronic format, nor was metadata developed.

This was considered an interim soil survey report by the NRCS, and eventually soil surveys meeting National Cooperative Soil Survey Standards (NCSS) will be completed for all of the soil survey areas that cover GLCA.

At the present time, the soils information that currently exists for GLCA and is in possession by NPS does not meet the requirements for soils data as part of the I&M program. Negotiations are currently underway with NRCS to acquire an updated soil survey that meets NCSS standards, and will match surrounding areas such as the Grand Staircase-Escalante NM, Capitol Reef NP, and other federal and private lands.

PALEONTOLOGICAL RESOURCES

Vince Santucci (NPS-GRD Paleontologist) presented an overview of paleontological resources for GLCA and the NPS in general. GRD provides support on policy and GPRA goals related to paleontological resources in parks. Paleontology is not currently part of the first level of the I&M program, but this may change in the future. Vince also mentioned the need for a mandate for protecting paleontological resources within federal lands. Vince has participated in refresher training courses for NPS rangers to make them more aware of the importance of realizing and protecting paleontological resources. A first step is to make parks realize if they have significant paleontological resources, and second is to conduct baseline inventories.

Norm Henderson (GLCA-natural resources) is interested in having a Paleontological Survey conducted for GLCA and RABR and has already approximately \$20,000 in funds designated for this. Similar studies have been done at Zion, Yellowstone and Death Valley. Vince Santucci (NPS-GRD Paleontologist) has offered to conduct such a survey for the park.

Similar surveys have shed valuable new information on previously unrecognized resources. These surveys involve a literature review/bibliography and recognition of type specimens, species lists, and maps (which are unpublished to protect locality information), and also make park specific recommendations for protecting and preserving the resources.

The Death Valley Survey will be available soon. The **Yellowstone** Survey is already available on-line at:

http://www.nature.nps.gov/grd/geology/paleo/yell_survey/index.htm

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and is also available as a downloadable PDF at
<http://www.nature.nps.gov/grd/geology/paleo/yell.pdf>

If a paleontological survey yields significant findings, paleontological resource management plans should be produced for Glen Canyon and Rainbow Bridge involving some inventory and monitoring to identify human and natural threats to these resources. Perhaps someone on the park staff could be assigned to coordinate paleontological resource management and incorporate any findings or suggestions into the parks general management plan (GMP). It would be useful to train park staff (including interpreters and law enforcement) in resource protection, as the fossil trade "black market" has become quite lucrative for sellers and often results in illegal collecting from federal lands.

Collections taken from this area that now reside in outside repositories should be tracked down for inventory purposes. Fossils offer many interpretive themes and combine a geology/biology link and should be utilized as much as possible in interpretive programs.

As the group saw along the field trip, the park has numerous vertebrate trackways. Santucci also mentioned that "dinosaur tracker" Martin Lockley (University of Colorado at Denver) has done some work in the area, and should be consulted for his findings and subsequent publications on the subject.

Also mentioned as being significant paleontological resources for GLCA are following:

- Petrified trees and associated termite burrows
- At least 3 dozen vertebrate track sites (ranging from the Permian Cedar Mesa to the Jurassic Morrison formations)
- skin impressions of a sauropod dinosaur near Bullfrog
- mammoth tracks under shallow alcove near 40 mile drainage (contact Larry Agenbroad and Jim Mead at Northern Arizona University for more information)
- invertebrate trace fossils in Cretaceous Tropic Shale and ammonites from "skip" zone; 3 plesiosaur localities in GLCA
- bones & petrified wood in Triassic Chinle Formation (phytosaur, metoposaur??)
- wood in Jurassic Navajo and Page sandstones
- Quaternary/Pleistocene sloth, mammoth, goat, pollen, pack-rat middens, dung deposits
- Pennsylvanian-Permian marine invertebrates in Honaker Trail Formation
- Cretaceous Dakota Sandstone exogyra (mollusk) fossils

GEOLOGIC MAPPING

UGS Perspective

Currently, the UGS is mapping in Utah at three different scales:

- **1:24,000** for high priority areas (i.e. National and State parks)

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- **1:100,000** for the rest of the state
- **1:500,000** for a compiled state geologic map

The UGS plans to complete mapping for the entire state of Utah within 10-15 years at **1:100,000** scale. For **1:100,000** scale maps, their goal is to produce *both* paper and digital maps; for **1:24,000** scale maps, the only digital products will be from "special interest" areas (i.e. areas such as Zion and growing metropolitan St. George). Grant Willis mentioned that the UGS simply does not have enough manpower and resources to do more areas at this scale. He also reiterated that UGS mapping goals are coincident with those of the National Geologic Mapping Program.

Current Status

Several (> 50) 7.5-minute quadrangles cover Glen Canyon NRA and Rainbow Bridge NM. ([see Appendix C, Glen Canyon NRA and Rainbow Bridge NM Index of Geologic Maps, 1:24,000 Scale, Panels 1-3](#)).

As of yet, there is no major synthesis of these quadrangles into a single map coverage for GLCA. It was agreed that developing a **1:24,000** scale geologic map is probably not realistic at this time given the expense of mapping and digitizing, so it was surmised to compile existing quadrangles and develop a **1:100,000** scale geologic map for GLCA.

Thus, the following was proposed:

- attain existing completed digital geologic data from the UGS for (3) 100,000 scale sheets that cover the GLCA area (Smokey Mountain, Escalante, and La Sal) and attribute them per the NPS geologic map model that Joe Gregson demonstrated
- digitize the existing map of the Arizona piece of GLCA ("*Geology of the Lees Ferry area, Coconino County, Arizona by D.A Phoenix*: U.S. Geological Survey Bulletin, No. 1137, 1963, scale: **1:24,000**). It was noted that the Page Sandstone is not identified on this map because it had not been identified at the time, and the Quaternary may need some refinement.
- jointly fund with the NPS and UGS to complete mapping of the Hites Crossing, Navajo Mountain and Hanksville **100,000** sheet quadrangles to complete the mapping of GLCA area
- Rainbow Bridge NM would be good to map at **1:6,000** scale; the current quadrangles covering the area are the Cummins Mesa SE and Navajo Mountain-13. Perhaps this would make a good EDMAP project.
- Norm Henderson would like to see more detailed mapping in administrative areas such as Wahweap, Bullfrog and Lees Ferry at **1:24,000** or better. These would not have to cover entire quadrangles, just the administrative centers. Also mentioned was the Rainbow Bridge quadrangle that has GLCA in the northwest corner to be more detail mapped.

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George Billingsley mentioned that Richard Hereford (USGS-Flagstaff) has mapped the area at 1:100,000 scale and is a Quaternary geologist, should he need consulted. He apparently also has a 1:6,000 map of Lees Ferry, Lonely Dale(??) and the Paria River System along the Colorado River at six foot contour intervals and detailed flood deposits too.

John Spence would like to see more detailed mapping of the Quaternary deposits within GLCA and thinks it can be done from aerial photographs. Grant Willis thought it would be reasonable to be able to break out units at 1:100,000 scale for eolian, lake, mass movement, alluvial fan, alluvial stream etc.

GRD is currently trying to track down Bureau of Reclamation maps of the dam area from the 1960s that are rumored to have 10 foot contour intervals to see if they would be useful in our GIS coverage.

OTHER SOURCES OF NATURAL RESOURCES DATA

- The UGS has a significant quadrangle database that they have furnished to NRID for the entire state of Utah.
- NRID has compiled a geologic bibliography for numerous parks and monuments, including Glen Canyon NRA and Rainbow Bridge NM. Visit the website at: <http://165.83.36.151/biblios/geobib.nsf>; **user id** is "geobib read", **password** is "anybody".
- Lex says he has some 353 maps at 1:4,800 scale with 10 foot contour intervals ranging from elevations of 3140-3750 feet
- Lex also mentioned indexed historical maps along the shoreline showing geologic hazards
- Vince has a manuscript on "Fossil Footprints in GLCA" from Lockley
- Abandoned Mineral Land (AML) database by John Burghardt (GRD)
- Many DOQQs for entire park from 1997 that still need indexed; they're only being archived now
- ANCS for paleontological specimens database (geology too)
- Pete Peterson (USGS) suggests some map sources from BLM proposed Wilderness areas of the Henry Basin that he did with USGS; should be in GeoBib (Dubiel as author ??); Pete did mineral potential evaluations

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GEOLOGIC HAZARDS

The following were recognized as geologic hazards:

- Rockfalls along the lake shores
 - Shrink-swell clays throughout area (Chinle, Tropic formations)
 - Uranium in Chinle Formation
 - Flash-floods in slot canyons and associated sediment resource issues below dam (important to dam operators for maintaining beaches)
 - Navajo Sandstone cement dissolution around dam (carbonate and silica)
-

POTENTIAL RESEARCH TOPICS FOR GLEN CANYON NRA AND RAINBOW BRIDGE NM

A list of potential research topics includes studies of the following:

- Paleoclimate change study for the area
- How are the Waterpockets maintained for biologic effects
- Silting studies for Lake Powell
- Recognize effects of GLCA on sediment resources downstream
- Change of ecology downstream from dam
- John Spence on Water chemistry: how permanent are springs (flowing since Pleistocene John thinks(?))
- Expand on unique features
- Why are Plume colors related to different water colors at different times of the year
- Map geologic hazards
- Paleontological inventory
- Studies of Rainbow Bridge stability

DISTURBED LANDS

- GRDs John Burghardt has done much work on Abandoned Mineral Lands (AML) and has written reports that are available from GRD
- some drill pads (get from Sprinkel the CD showing mineral and energy exploration localities in UT), uranium, tar sands
- grazing impacts need restoration
- old air strips (contact Ken McMillan, GLCA environmental specialist)

UNIQUE GEOLOGIC FEATURES

- Giant weathering pits in Entrada sandstone; strange deformation soft sediment features in Cookie Jar area; much disagreement about the origins
- Waterpocket fold; extends from CARE to GLCA area
- Rainbow Bridge

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- Hanging gardens; because they are geologically controlled
 - Tar sands at north end of GLCA
 - Arches
 - Limestone oasis deposits in Navajo Sandstone
 - Sand dunes
 - River cobbles at higher elevations
 - Burning coal beds from spontaneous combustion; length of burning unknown, but probably several hundred years, as it ignites on fresh exposures
 - Badlands and hoodoos in Tropic, Chinle, Morrison formations
 - Unconformities in geologic rock record
 - Geologic Type sections: Page, Romana, 50-Mile Member of Morrison, Honaker Trail (check for sure; seems to be in NPS boundaries)
 - Mud cracks and other sedimentary structures
 - Old soil horizons
 - Fresh scarps associated with landslides
 - Alcoves (not caves) in Navajo
 - Iron concretions, conchoidal fractures, desert varnish, slickrock, eolian sands, petrified sand dunes,
 - Narrow slot canyons
-

ACTION ITEMS

Many follow-up items were discussed during the course of the scoping session and are reiterated by category for quick reference.

Interpretation

- If desired consult with GRD's Jim Wood (jim_f_wood@nps.gov), UGS Sandy Eldredge(nrugs.seldredge@state.ut.us) or Melanie Moreno at the USGS-Menlo Park, CA (mmoreno@usgs.gov) for additional assistance with various interpretation themes

UGA Guidebook

- Attempt to plant the seeds of this concept to other states for similar publications involving local area geology. Such publications are especially useful for the GRI

Natural Resources

- Consult with Vince Santucci on the scheduling of a full paleontological survey for GLCA

Geologic Mapping

- Attempt to locate D.A Phoenix's greenlines to digitize from (Pete Peterson tried to locate but could not)
- Attempt to locate Bureau of Reclamation maps of Glen Canyon Dam from 1960s (10 foot contour intervals)

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Natural Resource Data Sources

- Lex Newcomb (GLCA-GIS) would like to obtain a copy of the geologic map of Utah (1:500,000 scale)
- Lex also mentioned historical maps along the shoreline showing geologic hazards; try to incorporate into hazards layer.
- It was mentioned that Martin Lockley has GPS locations of paleo localities that Vince would like to acquire; need to consult Lockley on this

Miscellaneous

- Review proposed research topics for future studies within Glen Canyon NRA and Rainbow Bridge NM
- Norm would like to establish a Memorandum of Understanding (MOU) with the Museum of Northern Arizona (MNA) in the event they became a repository for GLCA. Since Grand Canyon NP already has one, they should be consulted on the specifics
- Grant Willis mentioned that someone from the Indian Nation should have been invited to the meetings; Bruce Heise suggested Fernando Blackgoat as possible future contact to better develop ties for mapping on Indian land
- The UGS will need to develop a proposal for the NPS to get the mapping and digitizing done for Hites Crossing, Navajo Mountain, and Hanksville 1:100,000 sheets.

APPENDIX A

Glen Canyon NRA and Rainbow Bridge NM Geological Resources Inventory Workshop Participants

September 23-25, 1999

NAME	AFFILIATION	PHONE	E-MAIL	Thu. 9-23	Fri. 9-24	Sat. 9-25
Bruce Heise	NPS, Geologic Resources Division	(303) 969-2017	Bruce_Heise@nps.gov	X	X	X
Tim Connors	NPS, Geologic Resources Division	(303) 969-2093	Tim_Connors@nps.gov	X	X	X
Vince Santucci	NPS, Geologic Resources Division Fossil Butte NM, Wyoming	(307) 877-4455	Vincent_Santucci@nps.gov	X	X	X
Joe Gregson	NPS, Natural Resources Information Division	(970) 225-3559	Joe_Gregson@nps.gov	X	X	X
Pete Biggam	NPS, Natural Resources Information Division	(303) 987-6948	Pete_Biggam@nps.gov	X	X	X
Norm Henderson	NPS-GLCA	(520) 608-6272	Norm_Henderson@nps.gov	X	X	X
John Spence	NPS-GLCA	(520) 608-6267	John_Spence@nps.gov		X	X
Mark Anderson	NPS-GLCA	(520) 608-6377	Mark_Anderson@nps.gov		X	X
Lex Newcomb	NPS-GLCA	(520) 608-6271	Lex_Newcomb@nps.gov		X	
Ben Bobowski	NPS-GLCA	(520) 608-6274	Ben_Bobowski@nps.gov		X	
Lewis Boobar	NPS-GLCA	(520) 608-6266	Lewis_Boobar@nps.gov		X	
George Billingsley	USGS-Flagstaff, AZ	(520) 556-7198	Gbillingsley@usgs.gov	X	X	X
Pete Peterson	USGS-Denver, CO	(303) 236-1546	Fpeterson@usgs.gov	X	X	X
Christine Turner	USGS-Denver, CO	(303) 236-1561	Cturner@usgs.gov	X		X
Doug Sprinkel	Utah Geological Association	(801) 782-3398	Sprinkel@vii.com	X	X	X
Tom Chidsey	Utah Geological Association	(801) 537-3364	Nrugs.tchidsey@state.ut.us	X	X	X
Grant Willis	Utah Geological Survey	(801) 537-3355	Nrugs.gwillis@state.ut.us	X	X	X

APPENDIX B

Overview of Geologic Resources Inventory

The NPS Geologic Inventory is a collaborative effort of the NPS Geologic Resources Division (GRD) and Inventory and Monitoring Program (I&M) with assistance from the U.S. Geological Survey (USGS), American Association of State Geologists (AASG), and numerous individual volunteers and cooperators at NPS units, colleges, and universities.

From the perspective of the servicewide I&M Program, the primary focus (Level 1) of the geological inventory is

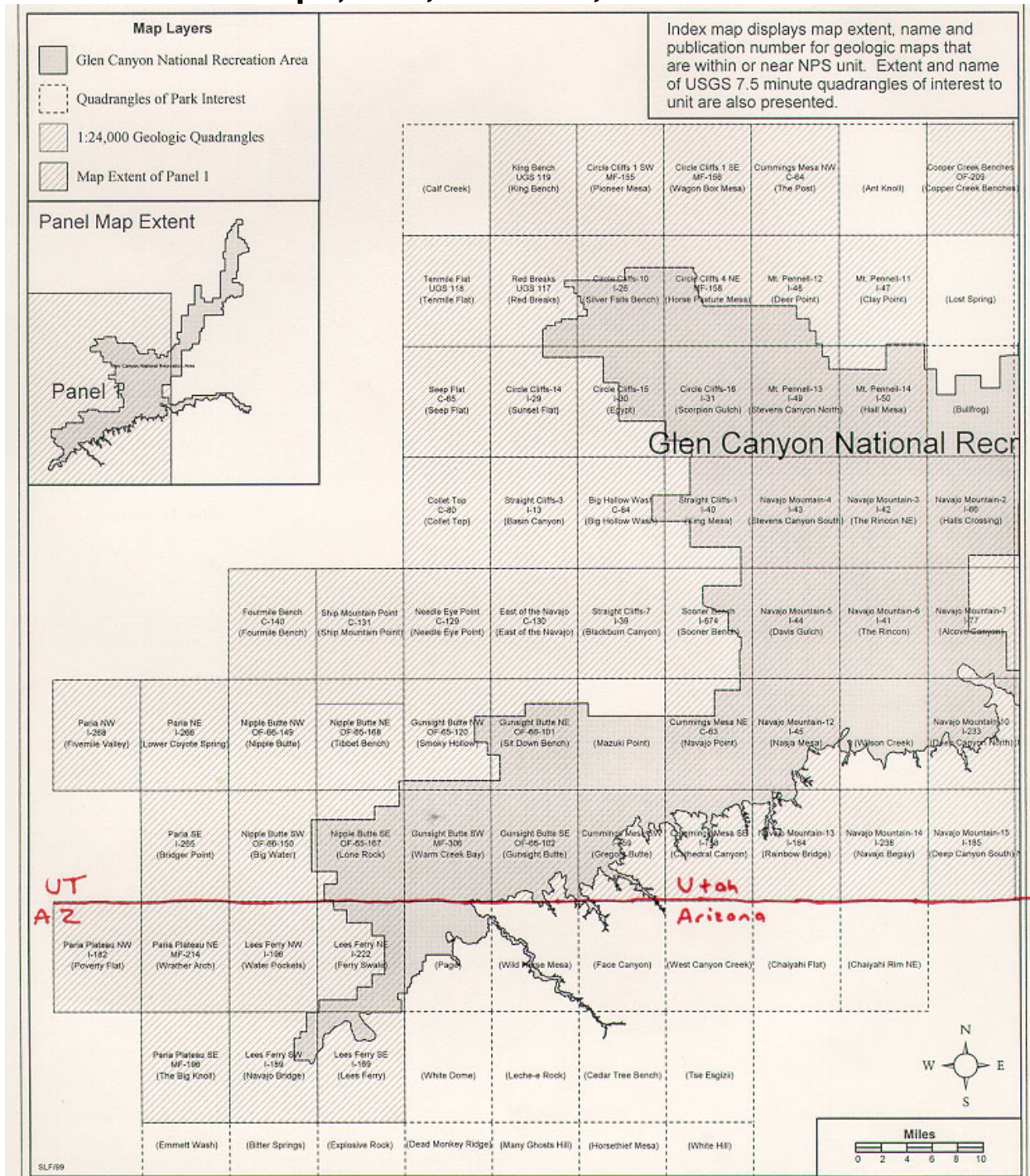
1. to assemble a bibliography of associated geological resources for NPS units with significant natural resources,
2. to compile and evaluate a list of existing geologic maps for each unit,
3. to develop digital geologic map products, and
4. to complete a geological report that synthesizes much of the existing geologic knowledge about each park. The emphasis of the inventory is not to routinely initiate new geologic mapping projects, but to aggregate existing information and identify where serious geologic data needs and issues exist in the National Park System.

The NPS Geologic Resources Division is an active participant in the I&M Program and has provided guidance and funding in the development of inventory goals and activities. GRD administers the Abandoned Mine Lands (AML) and Geologists In Parks (GIP) programs which contribute to the inventory. NPS paleontologists, geologists, and other natural resource professionals also contribute to inventory planning and data. A major goal of the collaborative effort is to provide a broad baseline of geologic data and scientific support to assist park managers with earth resource issues that may arise.

For each NPS unit, a cooperative group of geologists and NPS personnel (the Park Team) will be assembled to advise and assist with the inventory. Park Teams will meet at the each NPS unit to discuss and scope the geologic resources and inventory, which is the subject of this report. If needed, a second meeting will be held at a central office to evaluate available geologic maps for digital production. After the two meetings, digital geologic map products and a geologic report will be produced. The report will summarize the geologic inventory activities and basic geology topics for each park unit. Due to the variety of geologic settings throughout the NPS, each report will vary in subject matter covered, and section topics will be adapted as needed to describe the geologic resources of each unit. Whenever possible the scientific sections of the report will be written by knowledgeable cooperators and peer reviewed for accuracy and validity.

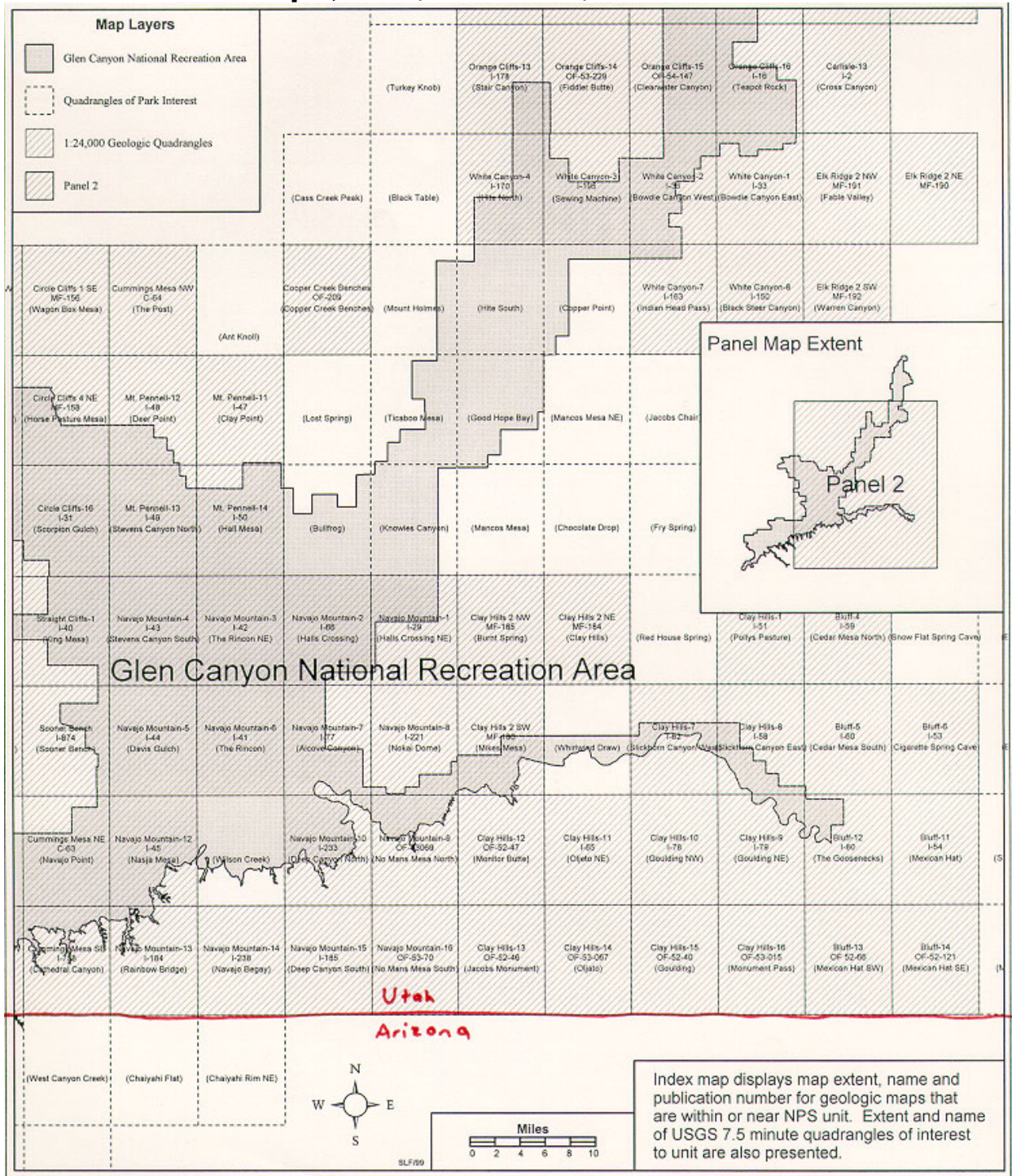
APPENDIX C

Glen Canyon NRA & Rainbow Bridge Index of Quadrangle Maps, 1:24,000 scale, Panels 1-3



APPENDIX C

Glen Canyon NRA & Rainbow Bridge Index of Quadrangle Maps, 1:24,000 scale, Panels 1-3



Index map displays map extent, name and publication number for geologic maps that are within or near NPS unit. Extent and name of USGS 7.5 minute quadrangles of interest to unit are also presented.

Map Layers

- Glen Canyon National Recreation Area
- Quadrangles of Park Interest
- 1:24,000 Geologic Quadrangles
- Panel 3

Glen Canyon National Recreation Area

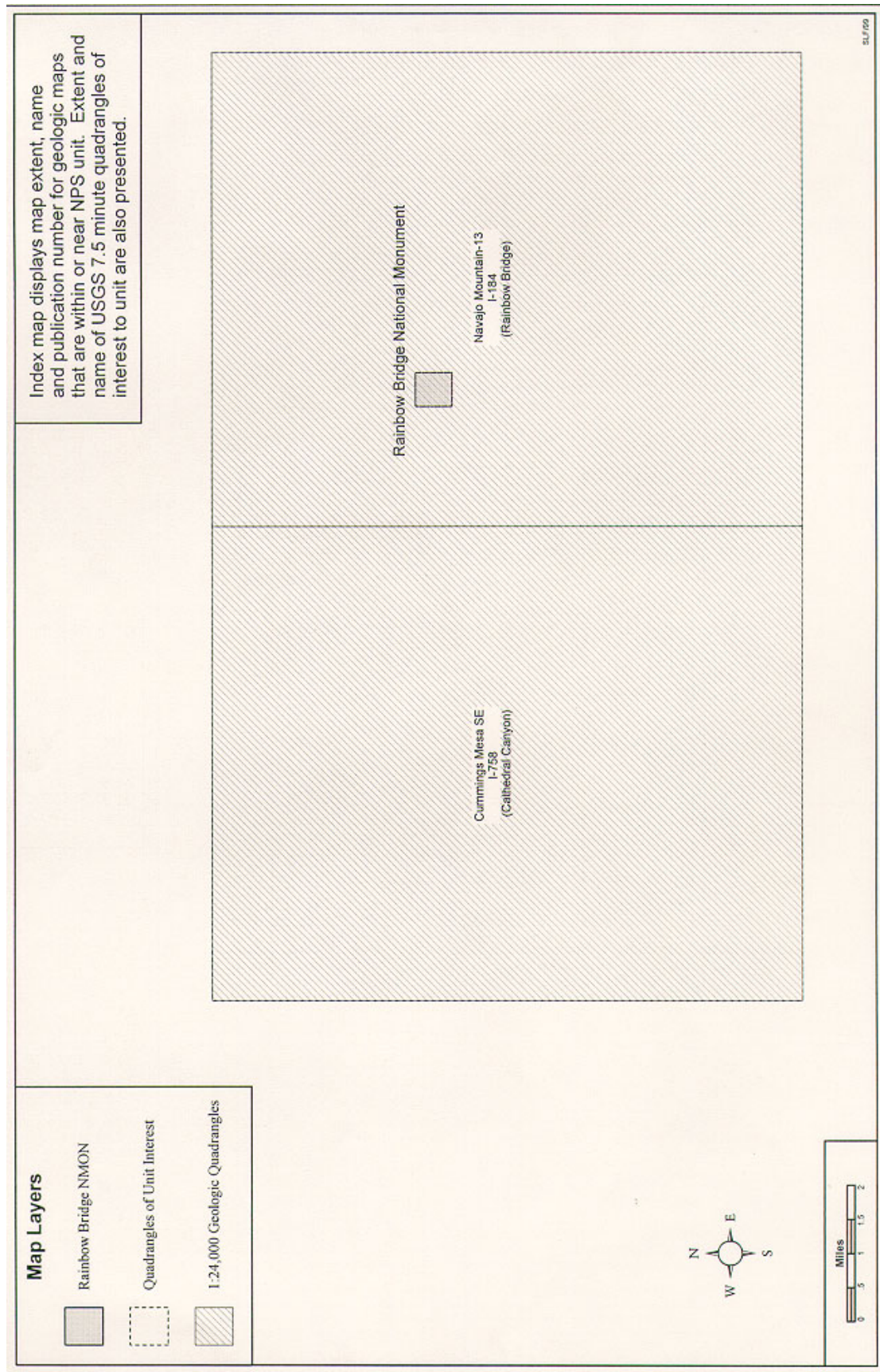
Panel 3

Panel Map Extent

Miles
0 2 4 6 8 10

APPENDIX C

Glen Canyon NRA & Rainbow Bridge Index of Quadrangle Maps, 1:24,000 scale, Panels 1-3



APPENDIX D

UGS Index of Quadrangle Maps, 1:100,000 scale

